and joint replacement: *where are we now?*

Obesity is a global epidemic of 2.1 billion people and a well know cause of osteoarthritis. Joint replacement in the obese attracts more complications, poorer outcomes and higher revision rates. It is a reversible condition and the fundamental principles of dealing with reversible medical conditions prior to elective total joint replacement should apply to obesity. The dilemma for orthopaedic surgeons is when to offer surgery in the face of a reversible condition, which if treated may obviate joint replacement and reduce the risk and severity of obesity related disease in both the medical arena and the field of orthopaedics.

T. Unsworth-Smith MBBS, B.App.Sci (HMS), B.Bus (Mkt)
Orthopaedic Registrar
Royal Perth Hospital
Perth CBD, Western Australia 6000, Australia

D. Wood FRCS, Fracs
Winthrop Professor
Hollywood Private Hospital
Monash Ave, Nedlands, Western Australia 6009, Australia
e-mail: david.wood@uwa.edu.au

THE SIZE OF THE PROBLEM

Obesity is a global epidemic affecting upwards of 2.1 billion people.[1,2] The obese are known to have an increased risk of coronary artery disease, hypertension, diabetes, peripheral vascular disease, obstructive sleep apnoea, hyperlipidemia, gastro-oesophageal reflux, gallstones, urinary stress incontinence, peripheral vascular disease, colon, breast and ovarian cancer, depression and other psychiatric disorders.[3,4] Our concern as orthopaedic surgeons is with the potential for increased incidence of osteoarthritis in the obese, the additional hazards of joint replacement surgery in this population and the associated medical ethics. Weight-bearing joints are abnormally and excessively loaded in obesity, causing articular cartilage failure. The metabolic influence of obesity potentiates this mechanical failure with an increased incidence of osteoarthritis and subsequently a more rapid degeneration.[4,5] The dilemma for the orthopaedic surgeon is when to offer surgery in the face of a reversible condition; if obesity is treated this may obviate joint replacement and reduce the risk and severity of obesity-related disease.

OBESITY, JOINT DISEASE AND TREATMENT

Total joint replacement (TJR) in the obese attracts more complications, poorer outcomes and higher revision rates.[6,7] Despite this, the vast majority of obese patients who undergo TJR are satisfied with these poorer than average outcomes and a strong argument can be made for arthroplasty treatment where effective obesity treatments are absent. The long list of comorbid diseases and increased surgical risks in obese patients demands multidisciplinary management. This is a demand rarely met. Diet and exercise programmes may be successful and results are sustained in a small proportion of patients, but modest temporary weight loss is more usual. About 340 000 bariatric operations are performed worldwide every year, providing rapid, effective and sustained weight loss and reduction in joint pain.[8] However, bariatric surgery is expensive and often inaccessible to non-privately funded patients. Although obesity in the developed world represents a problem comparable with smoking,[1,9] the political will to drive an effective public health programme and generate cultural change seems conspicuously absent. While these conditions prevail, orthopaedic surgeons will continue to be faced with the dilemma of either performing surgery in suboptimal conditions or allowing pain and disability to continue uncorrected as obesity is treated with mixed results.

The World Health Organization classifies obesity based on body mass index (BMI). The following table illustrates this classification:[10]

Table I. The World Health Organization (WHO) obesity classification, based on body mass index (BMI)[10]

WHO Classification	Body mass index
Underweight	< 18.5 kg/m²
Normal Weight	5 to 24.9 kg/m2
Overweight	25 to 29.9 kg/m²
Obese	> 30 kg/m²
Obese Class I	30 to 34.9kg/m²
Obese Class II	35 to 39.9 kg/m²
Obesity Class III	≥ 40 kg/m²

As the worldwide prevalence of obesity continues to increase, new terms are emerging. Specifically, studies are now examining patients with BMI > 45 to 50 kg/m2, which has been given the designation of 'super-obese'.[11,12]

EPIDEMIOLOGY

The number of prosthetic hip and knee replacements implanted in Australia has doubled over the last decade and the 63% of overweight or obese adult Australians are disproportionately represented.[13,14] Over 1.8 million Australians have arthritis at a cost of $1.2 billion for the 80 000 joint replacements performed each year.[14] This number will only increase as the average age and weight of our population increases.[14]

OBESITY A CAUSE OF OSTEOARTHRITIS

There is a strong causal relationship between obesity and osteoarthritis.[5,15-19]

In a report from the Canadian Joint Replacement Registry examining 17 244 joint replacement patients, obese persons were over three times more likely, and overweight persons were one and a half times more likely, to undergo joint replacement surgery than those of normal weight.[16] A work group from the American Association of Hip and Knee Surgeons (AAHKS) concluded from their literature-based review that there is clear evidence to indicate that obesity is associated with the development of osteoarthritis in the knee, but evidence in the hip was less clear.[6] The authors suggested that the obese population would be at greater risk for TJR and comprise an ever-increasing segment of the TJR population.[6] Although obesity in the younger population may be asymptomatic, a cumulative exposure to greater weight during young adult life is an important cause of subsequent osteoarthritis.[17,20,21] A study recording the BMI of 1180 medical students with a median follow-up of 36 years demonstrated that the incidence of knee osteoarthritis was strongly associated with a high BMI at 20 to 29 years and 30 to 39 years. For BMI assessed at ages 20 to 29 years, the incidence of knee osteoarthritis at age 65 years was 12.8% among the heaviest subjects (BMI range 24.7 to 37.6), threefold greater than the incidence of 4.0% in the leanest (BMI range 15.6 to 22.8).[20] These results were supported by the assessment of 1021 patients with clinically and radiologically diagnosed osteoarthritis where a high percentage of patients with end-stage hip OA are overweight, including younger adults.[17] There is a plethora of research suggesting obesity is both a direct and indirect risk factor for osteoarthritis. There is the direct mechanical mechanism where obesity leads to repetitive application of increased axial loading at the joint, higher contact pressures and subsequent degeneration of articular cartilage and sclerosis of subchondral bone. Secondly, obesity may lead to osteoarthritis through metabolic factors that adversely cause degradation of cartilage and hence act to potentiate the risk of knee OA.[6,22]

BARIATRIC SURGERY, WEIGHT LOSS AND OSTEOARTHRITIS

With sustained weight loss, the lighter load during mechanical cycling of joints reduces the inflammatory and biological stressors on the articular cartilage, and relief from the pain and disability of arthritis can be seen clinically within three months of bariatric surgery.[22-24]

Hooper et al[23] reported that 100% of obese patients in their study experienced musculoskeletal pain prior to bariatric surgery. This decreased to 23% following surgically-assisted weight loss (mean weight loss 41 +/-5 kg).[23] In a separate study, these results have been quantified and, using a visual analogue scale and/or the Western Ontario and McMaster Universities Arthritis Index (WOMAC)[25] score, a 20% weight loss over six months decreased scores for pain by 50%, and improved function by 57%.[24]

Behavioural and pharmacological treatments for obesity are less effective than bariatric surgery and usually result in short-term weight loss of approximately 5% to 10% body weight.[26] There is a dose-response relationship between changes in body weight and corresponding changes in pain and function in the joints. The threshold for this response gradient has been quantified and appears to be seen with body weight shifts of ≥ 10%, which have the potential to lead to important changes in pain and function.[27] Patients frequently present the clinician with the argument that they would be able to exercise and lose weight if their arthritic pain was effectively treated. It has long been accepted that this is not the case, and that TJR has not been shown to be an effective weight reduction intervention.[28]

COMPLICATIONS

There is compelling evidence that the 'super-obese' (BMI > 45) have an increased risk of peri-operative complications when undergoing TJR. There is an odds ratio (OR) of around 8.44 for the development of in-hospital complications following arthroplasty in the 'super-obese'. Interestingly each incremental 5-unit increase in BMI above 45 is associated with an increased risk of in-hospital (OR, 1.69) and outpatient complications (OR, 2.71) and has the same effect on readmission (OR, 2.0). Length of stay was similarly increased by 13.8% for each 5-unit increase in BMI above 45.[29] The impact of obesity continues to become more significant as patients' BMI increases above 45.

There are a number of reports that the obese have an increased risk of wound complications, infection, venous thromboembolism, hip dislocation, revision surgery, increased length of stay and poorer outcomes from TJR.[6,7,29,30] The overall incidence of these complications in percentage terms is low, and large sample sizes are required to show a significant difference. Consequently there are a number of underpowered reports in the literature that fail to achieve significance due to low sample size.[30,31]

REVISION

The combination of a high infection risk and abnormally high physical loads increases revision rates in obese patients. A meta-analysis of 11 studies and 12 101 patients concluded that revision for any reason occurred more often in obese patients, with an OR of 1.30 (95% confidence interval (CI) 1.02 to 1.67).[7] Another meta-analysis by Haverkamp et al[30] showed higher rates of aseptic loosening occurring in patients with a BMI of > 30. This corroborates a report of a series of 562 primary total knee replacements (TKR) in which there was a higher revision rate in obese patients (BMI > 30) with a survival rate of 92.74% at ten years compared with those with a BMI < 30 who had a survival of 98.45% ($p = 0.0015$).[32] A conflicting finding was reported in a simple regression analysis of 9735 TKR patients, where implant failure was not influenced by BMI, absolute body weight, or gender.[33] Our view concurs with the authors of the two meta-analyses with good evidence to support the relationship between obesity and increased revision rates.

INFECTION

The same American work group[6] who confirmed obesity as a cause of osteoarthritis by evaluating the current literature showed that there is a clear increase in wound healing complications and deep infection in obese patients undergoing TJR.[6]

The blood supply to wide layers of subcutaneous fat is poor; this tissue heals more slowly and is susceptible to wound breakdown and deep infection, a devastating complication. With higher rates of revision surgery, long-term antibiotics, chronic infection, amputation and a two to three times higher risk of death in a patient with sepsis it is no wonder that surgeons are hesitant to perform arthroplasty surgery in obese patients.[3] A recent meta-analysis and systematic review of journal articles between 1970 and 2009 concluded that obese patients undergoing TKR had increased rates of infection with an OR of 2.38 (95% CI 1.28 to 4.55) for deep infection and higher rates of revision with an OR of 1.30 (95% CI 1.02 to 1.67) when compared with non-obese patients undergoing TKR.[7] These results are similar to the pooled results of a meta-analysis consisting of ten eligible studies with a cumulative total of 7500 patients. The risk of infection was three times greater in the obese population post total hip replacement (THR) or TKR when compared with non-obese patients.[30] A review of the literature from 1990 to 2007 on THR and TKR showed a correlation between obesity and complications. Obesity was found to be a specific risk factor for joint infection.[31] In a large study of 7181 patients using a number of statistical analyses, both diabetes and obesity independently increased post-operative infection rates, and rates were even higher in morbidly obese patients with diabetes.[34] This situation is made worse by increasing incidence of obesity, and a second study looking at 'super-obese' patients with a large sample size (8494 TJRs) and a BMI > 50 had an increased OR of infection of 21.3 ($p < 0.0001$).[35] Some series have reported a counter finding that there is no correlation between obesity and post-operative complications following lower limb arthroplasty.[36-40] Because of low rates of complications in all arthroplasty surgery, large numbers of participants are needed to validate hypotheses. Unfortunately, there are large numbers of studies with poor sample sizes that are both supporting as well as countering the claims that obese patients undergoing TJR have an increased risk of complications. The meta-analyses and systematic reviews support the conclusion that obesity is a risk factor for post-operative wound and joint infection.

VENOUS THROMBOEMBOLISM

The obese population is already at increased risk of venous thromboembolism (VTE). VTE, combined with lower limb surgery and slower mobilisation, places obese patients at greater

risk. A meta-analysis including seven studies and 5137 patients analysing the risk of VTE in obese versus non-obese patients showed an increased risk in obese patients following THR when compared with their non-obese counterparts.[30] Once again, there have been a number of studies that confirmed this finding.[40-42] The 2012 meta-analysis that combined 14 studies with a total of 15 276 patients also demonstrated a difference between obese and non-obese patients with regards to VTE incidence rates.[30] There were few studies that showed no difference in rates of VTE when comparing obese and non-obese patients.[31,43]

DISLOCATION

Recent papers, including a meta-analysis of ten studies, showed that dislocation occurred more often in patients with a BMI > 30 (OR = 0.5, CI 0.38 to 0.75).[30] This was supported by a large study in 2008 involving 2106 patients followed over eight years, demonstrating that overweight and obese patients were associated with increased risk of implant dislocation when compared with patients of normal weight.[44]

LENGTH OF STAY

The literature-based review by the American Association of Hip and Knee Surgeons demonstrated an increased length of stay and associated increased cost for obese patients when compared with non-obese patients.[6] This corroborates the findings of Ersozlu et al[45] who also found a significant difference in length of stay between obese patients and non-obese patients undergoing bilateral staged TKR. In a multivariate analysis an increasing BMI was significantly associated with an increased mean length of stay ($p < 0.001$),[46] and a significantly longer hospital stay has been independently reported in the super-obese category.[11] Batsis et al[47] however, retrospectively examined 5521 patients who underwent surgery for TKR. The adjusted length of stay was no different between normal (4.85 days), overweight (4.84 days), obese (4.86 days), or morbidly obese patients (4.93 days) ($p = 0.30$). There was no description for criteria of discharge nor to where they were discharged.

OUTCOMES

In a meta-analysis including 1805 patients, only the Harris hip score (HHS)[48] was used often enough to allow data pooling. Five studies were used with an inclusion criterion of a follow-up period of two or more years. A significant difference was noted with obese patients having a lower HHS compared with non-obese patients.[30] Dowsey et al[31] also showed lower HHS but no difference in quality of life scores associated with obesity. Of the remaining recent meta-analyses and systematic reviews used in this review that examined outcomes, the only conclusion that can be made is that the evidence was inconclusive.[6] This same review stated that obese patients have similar satisfaction rates to the non-obese population following TJR. As BMI increases (> 40), however, the functional improvement is lower than average, occurs more gradually and patients have an increased complication risk.[6] A large study in 2008 with a sample size of 18 968 patients showed that high pre-operative BMI is associated with an almost perfect dose–effect relationship with decreased ambulation during a follow-up period of 15 years. They did, however, stress that one of the most important goals of implanting an artificial hip joint – namely pain reduction – was similarly accomplished in obese patients as in the normal weight group.[49] In a series of 535 consecutive primary cementless TKRs with a mean follow-up of 9.2 years there was significantly lower mean improvement in the clinical score ($p = 0.044$) and lower post-operative total clinical scores in the obese group ($p = 0.041$) using Hospital for Special Surgery score[50] and knee flexion, but the results were still good and high patient satisfaction should be expected in patients undergoing TKR, irrespective of BMI.[51] A large proportion of recent studies have also shown no significant difference in outcomes between obese and non-obese patients. Sample size, however, for these recent studies varied from 30 to 3290 patients.[11,52-55] In the largest of these studies,[55] THR was performed in 3290 osteoarthritic patients with a minimum follow-up of two years. In this study the pre- and post-operative scores were lower for the group classified as morbidly obese, however, the overall change in outcome scores (using HHS and WOMAC) suggested an equal if not greater improvement compared with the non-morbidly obese patients.[55] Andrew et al[56] undertook a prospective, multi-centre study examining 1421 THRs between January 1999 and July 2007 to examine if obesity has an effect on clinical outcomes. They concluded that there was no statistically significant change in Oxford hip scores[57] and hence obese and morbidly obese patients have as much to gain from THR as non-obese patients.[56]

CONCLUSION

Obesity causes osteoarthritis and once established, if obesity persists, joint degeneration is accelerated. Obesity is potentially preventable and reversible, in contrast to osteoarthritis, and should, if possible, be addressed before TJR is considered. The fundamental principle of dealing with reversible medical conditions prior to elective TJR applies to obesity as well. Successful weight loss can obviate unnecessary TJR, delay orthopaedic intervention and improve outcomes if surgery still needs to be undertaken. Unfortunately, effective weight reduction treatment is expensive and not universally available. It is the exception rather than the rule to find multidisciplinary weight reduction teams available for coordinated management in public health systems. The super-obese represent a category of patients whose medical condition is so severe that the risk of surgery is unacceptable. With an OR for infection of > 20 it may be considered unethical to offer the super-obese TJR.

When an orthopaedic surgeon considers treatment in the obese patient with established end-stage osteoarthritis the options are:

1. Discuss the additional risk of complications, high rates of revision, and poor outcomes specific to TJR in the obese and, having informed the patient, offer them surgery irrespective of their weight
2. Set a target weight before offering the informed patient surgery, leaving the responsibility for weight reduction to the patient and family doctor
3. Directly refer patients for weight reduction

by diet, medical management, psychiatric assessment, bariatric surgery or a combination of these, depending on the weight and preference of the patient.

Patient compliance with a programme of weight loss by diet and exercise can be used as a barometer of the patient's motivation and an indicator of their ability to cope with the challenge of rehabilitation, particularly following TKR surgery. The high satisfaction rates following TJR in the obese is a powerful argument for surgery, and if mediocre functional results are acceptable to the patient and surgeon, TJR can be considered. The concept of what is an acceptable complication rate may change as we progress through the era of detailed open disclosure and this is likely to lead to a fall in rates of joint replacement in the obese. Obesity levels are rising rapidly, and rates of hip and knee osteoarthritis are increasing in conjunction with these numbers. The causal relationship between obesity and osteoarthritis is well established and with the number of obese patients suffering from pain and poor function, a multidisciplinary approach to the treatment of obesity is the optimal approach. Support for the wider implementation of these multidisciplinary units has been limited by cost and a lack of political support within and without the medical profession. There is an argument that obesity is a lifestyle choice rather than a disease and that public health measures and legislation to reduce access to the type of nutrition responsible for weight gain is preferable to dealing with the end result of obesity. Freedom of choice is used as an argument against social change. The same arguments were used against the bans on smoking in public places and restrictions on cigarette adverts. Few would now argue against the substantial health benefits of the programmes against tobacco. The obesity epidemic has had a similar impact on health to smoking and requires similar measures. Until these measures are introduced, orthopaedic surgeons will be left with the ethical and medical challenge of TJR in the obese.

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